

WHAT IS CLAIMED IS:

1           1.       A method for forming a consistency group of data, comprising:  
2           receiving a command to form a consistency group with respect to data received at  
3 a first storage site that is mirrored to a second storage site;  
4           providing a first data structure indicating updates to the first storage site not  
5 included in the consistency group that are received after the command;  
6           providing a second data structure indicating updates to the first storage site in the  
7 consistency group to be formed;  
8           transmitting a command to cause data copied to the second storage site that is part  
9 of the consistency group to be copied to a third storage site;  
10          receiving indication when the data in the second storage site that is part of the  
11 consistency group is copied to the third storage site.

1           2.       The method of claim 1, further comprising:  
2           maintaining a flag indicating which of the first and second data structures to use  
3 to indicate updates received after the command to form the consistency group; and  
4           toggling the flag to indicate the data structure not currently indicated by the flag,  
5 wherein the flag identifies the data structure that indicates updates to the first storage site  
6 not included in the consistency group.

1           3.       The method of claim 1, further comprising:  
2           detecting a failure at the second storage site;  
3           determining whether the data in the consistency group was copied to the third  
4 storage site; and  
5           copying the updates at the first storage site indicated in the first data structure to  
6 the third storage site after determining that the data in the consistency group was copied  
7 to the third storage site.

1           4.     The method of claim 3, further comprising:  
2           copying the data at the first storage site indicated in the first and second data  
3 structures to the third storage site after determining that the data in the consistency group  
4 was not copied to the third storage site.

1           5.     The method of claim 4, further comprising:  
2           merging data indicated in the first and second data structures into one of the data  
3 structures to indicate data in the consistency group that needs to be copied to the third  
4 site, wherein the other of the data structures is used to indicate updates to data that is not  
5 in the consistency group.

1           6.     The method of claim 1, further comprising:  
2           synchronously copying updates from the first storage site to the second storage  
3 site, wherein the data structures indicate updates to the first storage site that were  
4 successfully synchronously copied to the second storage site.

1           7.     The method of claim 1, wherein the first and second storage sites are  
2 separated by a first distance and the second and third storage sites are separated by a  
3 second distance, wherein the second distance is substantially greater than the first  
4 distance.

1           8.     A method for forming a consistency group of updates received at a first  
2 storage site, comprising:  
3           receiving at a second storage site updates from the first storage site;  
4           providing a first data structure indicating updates at the second storage site to  
5 copy to a third storage site;  
6           receiving a command to form a consistency group;

7           using a second data structure at the second storage site to indicate updates  
8   received from the first storage site after receiving the command that are not included in  
9   the consistency group to be formed; and  
10          signaling the first storage site in response to copying the updates in the  
11   consistency group indicated in the first data structure to a third storage site.

1           9.     The method of claim 8, further comprising:  
2           merging indications of updates in the first and second data structures into the first  
3   data structure in response to copying the updates in the consistency group indicated in the  
4   first data structure to the third storage site; and  
5           indicating in the second data structure updates from the first storage site received  
6   after merging the first and second data structure.

1           10.    The method of claim 8, further comprising:  
2           continuously asynchronously copying the updates indicated in the first data  
3   structure to the remote site.

1           11.    The method of claim 8, further comprising:  
2           determining whether the second data structure is being used to indicate updates  
3   from the first storage site not in one consistency group in response to receiving the  
4   command to form the consistency group;  
5           merging indications of updates in the first and second data structures in the first  
6   data structure in response to receiving the command to form the consistency group and  
7   determining that the second data structure is being used to indicate updates from the first  
8   storage site not in one consistency group; and  
9           indicating in the second data structure updates from the first storage site received  
10   after merging the first and second data structure.

1           12.    A system for forming a consistency group of data at a first storage that is  
2 in communication with a second storage site, comprising:  
3           a computer readable medium;  
4           means for receiving a command to form a consistency group with respect to data  
5 received at the first storage site that is mirrored to the second storage site;  
6           means for providing a first data structure in the computer readable medium  
7 indicating updates to the first storage site not included in the consistency group that are  
8 received after the command;  
9           means for providing a second data structure in the computer readable medium  
10 indicating updates to the first storage site in the consistency group to be formed;  
11           means for transmitting a command to cause data copied to the second storage site  
12 that is part of the consistency group to be copied to a third storage site;  
13           means for receiving indication when the data in the second storage site that is part  
14 of the consistency group is copied to the third storage site.

1           13.    The system of claim 12, further comprising:  
2           means for maintaining a flag in the computer readable medium indicating which  
3 of the first and second data structures to use to indicate updates received after the  
4 command to form the consistency group; and  
5           means for toggling the flag to indicate the data structure not currently indicated  
6 by the flag, wherein the flag identifies the data structure that indicates updates to the first  
7 storage site not included in the consistency group.

1           14.    The system of claim 12, further comprising:  
2           means for detecting a failure at the second storage site;  
3           means for determining whether the data in the consistency group was copied to  
4 the third storage site; and

5 means for copying the updates at the first storage site indicated in the first data  
6 structure to the third storage site after determining that the data in the consistency group  
7 was copied to the third storage site.

1 15. The system of claim 14, further comprising:  
2 means for copying the data at the first storage site indicated in the first and second  
3 data structures to the third storage site after determining that the data in the consistency  
4 group was not copied to the third storage site.

1 16. The system of claim 15, further comprising:  
2 means for merging data indicated in the first and second data structures into one  
3 of the data structures to indicate data in the consistency group that needs to be copied to  
4 the third site, wherein the other of the data structures is used to indicate updates to data  
5 that is not in the consistency group.

1 17. The system of claim 12, further comprising:  
2 means for synchronously copying updates from the first storage site to the second  
3 storage site, wherein the data structures indicate updates to the first storage site that were  
4 successfully synchronously copied to the second storage site.

1 18. The system of claim 12, wherein the first and second storage sites are  
2 separated by a first distance and the second and third storage sites are separated by a  
3 second distance, wherein the second distance is substantially greater than the first  
4 distance.

1 19. A system for forming a consistency group of updates received at a first  
2 storage site, wherein the system is located at a second storage site in communication with  
3 the first storage site, comprising:  
4 a computer readable medium;

5 receiving at a second storage site updates from the first storage site;  
6 providing a first data structure in the computer readable medium indicating  
7 updates at the second storage site to copy to a third storage site;  
8 receiving a command to form a consistency group;  
9 using a second data structure in the computer readable medium to indicate  
10 updates received from the first storage site after receiving the command that are not  
11 included in the consistency group to be formed; and  
12 signaling the first storage site in response to copying the updates in the  
13 consistency group indicated in the first data structure to a third storage site.

1 20. The system of claim 19, further comprising:  
2 means for merging indications of updates in the first and second data structures  
3 into the first data structure in response to copying the updates in the consistency group  
4 indicated in the first data structure to the third storage site; and  
5 means for indicating in the second data structure updates from the first storage  
6 site received after merging the first and second data structure.

1 21. The system of claim 19, further comprising:  
2 means for continuously asynchronously copying the updates indicated in the first  
3 data structure to the remote site.

1 22. The system of claim 19, further comprising:  
2 means for determining whether the second data structure is being used to indicate  
3 updates from the first storage site not in one consistency group in response to receiving  
4 the command to form the consistency group;  
5 means for merging indications of updates in the first and second data structures in  
6 the first data structure in response to receiving the command to form the consistency  
7 group and determining that the second data structure is being used to indicate updates  
8 from the first storage site not in one consistency group; and

9 means for indicating in the second data structure updates from the first storage  
10 site received after merging the first and second data structure.

1 23. An article of manufacture for forming a consistency group of data,  
2 wherein the article of manufacture is implemented at a first storage site in communication  
3 with a second site, and wherein the article of manufacture causes operations to be  
4 performed at the first storage site, the operations comprising:  
5 receiving a command to form a consistency group with respect to data received at  
6 a first storage site that is mirrored to a second storage site;  
7 providing a first data structure indicating updates to the first storage site not  
8 included in the consistency group that are received after the command;  
9 providing a second data structure indicating updates to the first storage site in the  
10 consistency group to be formed;  
11 transmitting a command to cause data copied to the second storage site that is part  
12 of the consistency group to be copied to a third storage site;  
13 receiving indication when the data in the second storage site that is part of the  
14 consistency group is copied to the third storage site.

1 24. The article of manufacture of claim 23, wherein the operations further  
2 comprise:  
3 maintaining a flag indicating which of the first and second data structures to use  
4 to indicate updates received after the command to form the consistency group; and  
5 toggling the flag to indicate the data structure not currently indicated by the flag,  
6 wherein the flag identifies the data structure that indicates updates to the first storage site  
7 not included in the consistency group.

1 25. The article of manufacture of claim 23, wherein the operations further  
2 comprise:  
3 detecting a failure at the second storage site;

4           determining whether the data in the consistency group was copied to the third  
5 storage site; and  
6           copying the updates at the first storage site indicated in the first data structure to  
7 the third storage site after determining that the data in the consistency group was copied  
8 to the third storage site.

1           26.    The article of manufacture of claim 25, wherein the operations further  
2 comprise:  
3           copying the data at the first storage site indicated in the first and second data  
4 structures to the third storage site after determining that the data in the consistency group  
5 was not copied to the third storage site.

1           27.    The article of manufacture of claim 26, wherein the operations further  
2 comprise:  
3           merging data indicated in the first and second data structures into one of the data  
4 structures to indicate data in the consistency group that needs to be copied to the third  
5 site, wherein the other of the data structures is used to indicate updates to data that is not  
6 in the consistency group.

1           28.    The article of manufacture of claim 23, wherein the operations further  
2 comprise:  
3           synchronously copying updates from the first storage site to the second storage  
4 site, wherein the data structures indicate updates to the first storage site that were  
5 successfully synchronously copied to the second storage site.

1           29.    The article of manufacture of claim 23, wherein the first and second  
2 storage sites are separated by a first distance and the second and third storage sites are  
3 separated by a second distance, wherein the second distance is substantially greater than  
4 the first distance.



1           30.    An article of manufacture for forming a consistency group of updates  
2   received at a first storage site, wherein the article of manufacture is implemented in a  
3   second storage site in communication with the first storage site, and wherein the article of  
4   manufacture causes operations to be performed, the operations comprising:  
5       receiving at a second storage site updates from the first storage site;  
6       providing a first data structure indicating updates at the second storage site to  
7   copy to a third storage site;  
8       receiving a command to form a consistency group;  
9       using a second data structure at the second storage site to indicate updates  
10   received from the first storage site after receiving the command that are not included in  
11   the consistency group to be formed; and  
12       signaling the first storage site in response to copying the updates in the  
13   consistency group indicated in the first data structure to a third storage site.

1           31.    The article of manufacture of claim 30, wherein the operations further  
2   comprise:  
3       merging indications of updates in the first and second data structures into the first  
4   data structure in response to copying the updates in the consistency group indicated in the  
5   first data structure to the third storage site; and  
6       indicating in the second data structure updates from the first storage site received  
7   after merging the first and second data structure.

1           32.    The article of manufacture of claim 30, wherein the operations further  
2   comprise:  
3       continuously asynchronously copying the updates indicated in the first data  
4   structure to the remote site.

1           33.    The article of manufacture of claim 30, wherein the operations further  
2   comprise:

3           determining whether the second data structure is being used to indicate updates  
4   from the first storage site not in one consistency group in response to receiving the  
5   command to form the consistency group;  
6           merging indications of updates in the first and second data structures in the first  
7   data structure in response to receiving the command to form the consistency group and  
8   determining that the second data structure is being used to indicate updates from the first  
9   storage site not in one consistency group; and  
10          indicating in the second data structure updates from the first storage site received  
11   after merging the first and second data structure.